# PATENT ABSTRACTS OF JAPAN

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## (54) MANUFACTURE OF NON-MAGNETIC WELDED WIRE GAUZE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a manufacturing method of a high Mn steel-made non- magnetic welded wire gauze having high joining strength by using a hot-rolled steel wire as it is.

SOLUTION: The high Mn steel having the compsn. contg. by wt., 0.10-1.5% C and 5-30% Mn is hot-rolled and coiled at ≥950°C and thereafter, this coil is corrected into a straight wire. Successively, the corrected straight shaped high Mn steel wire is arranged in a net-state and an electric resistance welding is executed to points of intersection. The characteristic of the welded wire gauze as the finish product is improved by cooling the coiled wire down to a temp. range of ≤300°C at ≥5°C/sec cooling rate after coiling the wire in a coil-state. In the case of containing further 3-6% Cr and 0.1-1.0% V in the above high Mn steel, the strength and the corrosion resistance are improved.

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TITLE: Non-magnetic welded metal mesh prodn. for motor car for high strength - by hot rolling high manganese steel, coiling, straightening, arranging wire in mesh pattern and electric welding crossing points

PATENT-ASSIGNEE: SUMITOMO METAL IND LTD[SUMQ]

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ABSTRACTED-PUB-NO: JP 09085372A

BASIC-ABSTRACT:

Prodn. comprises hot-rolling the high Mn steel contg. 0.10-1.5% C and 5-30% Mn, by wt., and coiling at 950 deg. C or above, straightening, arranging the straight wire in mesh pattern, and electric welding the crossing points on the mesh.

USE - Road base of linear motor car, compass check apron in airport.

ADVANTAGE - High joining strength is obtd. by processing in a hot-rolling state which decreases the prodn. cost.

CHOSEN-DRAWING: Dwg.0/2

TITLE-TERMS: NON MAGNETIC WELD METAL MESH PRODUCE MOTOR CAR HIGH STRENGTH HOT

ROLL HIGH MANGANESE STEEL COIL STRAIGHTENING ARRANGE **WIRE MESH PATTERN ELECTRIC WELD CROSS** POINT

DERWENT-CLASS: L03 M27 P52 P55

CPI-CODES: L03-A01A5; L03-H05; M24-D01A; M27-A04; M27-A04M;

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## CLAIMS

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[Claim(s)]
[Claim 1] The manufacture approach of the nonmagnetic welded wire mesh characterized by arranging the high Mn steel wire of the shape of a straight line which rolled out the high Mn steel containing C:0.10 - 1.5%, and Mn:5-30% between heat, rolled round to the coiled form at the temperature of 950 degrees C or more, corrected in the shape of a straight line after that, and was subsequently corrected by weight % in the shape of a mesh, and welding those intersections by electric resistance.
[Claim 2] After rolling out between heat the high Mn steel which contains C:0.10 - 1.5%, and Mn:5-30% by weight % and rolling round to a coiled form at the temperature of 950 degrees C or more, it cools to the temperature of a temperature region 300 degrees C or less with the cooling rate of 5 degrees C/second or more. The manufacture approach of the nonmagnetic welded wire mesh characterized by arranging the high Mn steel wire of the shape of a straight line which corrected in the shape of a straight line after that, and was subsequently corrected in the shape of a mesh, and welding those intersections by electric resistance.
[Claim 3] The manufacture approach of a nonmagnetic welded wire mesh given in either of claims 1 and 2 which are those in which high Mn steel is weight % and contains Cr 3 to 6% further.
[Claim 4] The manufacture approach of a nonmagnetic welded wire mesh given in either to claims 1-3 which are those in which high Mn steel is weight % and contains V 0.1 to 1.0% further.

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[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the approach of manufacturing the high Mn steel nonmagnetic welded wire mesh used for the concrete structures, such as a subgrade of a linear motor car, and a compass check apron of an airport, or reinforcement of those using the steel wire of a hot rolling as, in more detail about the manufacture approach of a nonmagnetic welded wire mesh.
[0002]
[Description of the Prior Art] In order that structural members, such as a subgrade of a linear motor car and a nuclear fusion reactor, may prevent magnetization, generation of heat, etc. all over a high magnetic field, and in order that the structural member of the compass check apron of an airport may enable the compass check of the aircraft, nonmagnetic steel material with low permeability is used. Also in such a nonmagnetic structural member, the high Mn steel generally called the so-called "Hadfield steel", such as austenitic stainless steel, such as SUS304 of JIS, and SCMnH2, has been used for the material of the welded wire mesh used as the object for the concrete structures, and an object for reinforcement.
[0003] However, since austenitic stainless steel contained expensive nickel and expensive Cr so much, since the yield point was low, it had the problem that the dimension (path) of a material had to be enlarged, at an expensive price. In addition, it was what causes the further cost rise to enlarge a dimension.
[0004] On the other hand, high Mn steel is high intensity, and shows nonmagnetic [ stable ], and is still cheaper compared with austenitic stainless steel. However, since there was a problem in respect of weldability, manual use of iron rods and union were performed, and construction had taken great cost.
[0005] As the manufacture approach of a high Mn steel wire gauze, after carrying out bending of the high Mn steel wire to the shape of a wave at JP,60-40498,B, the manufacture approach of a crimp wire gauze of knitting between wavelike on a network is proposed. However, the bonding strength of the wire gauze manufactured by this approach does not bear use as the object for the concrete structures, and an object for reinforcement low.
[0006] On the other hand, the "nonmagnetic high manganese steel excellent in weldability and machinability" which contains nickel 0.3 to 3.0% of the weight is proposed by JP,57-40901,B. However, only by arranging the steel wire of a hot rolling as in the shape of a mesh, and welding those intersections by electric resistance, even if it uses as a material the high Mn steel proposed by said official report, even if the welding point could separate or it could join, bonding strength was low. This is for the oxide (henceforth a "scale") produced with hot rolling to degrade the junction nature at the time of electric resistance welding.
[0007] That is, in the front face of the hot-rolled ferrous material, they are FeO, Fe 2O3, and Fe 3O4. Although an oxide generates, in the case of high Mn steel, in addition to these, high-melting Mn oxide generates at coincidence, and this degrades the junction nature at the time of electric resistance welding. Therefore, in order to give bonding strength sufficient by electric resistance welding, it is necessary to

carry out peeling of the hot-rolled high Mn steel wire, or to pickle it, and to remove high-melting Mn oxide also in a scale. However, in this case, a production process will become complicated and cost will also increase further.

[0008]

[Problem(s) to be Solved by the Invention] This invention was made in view of the above-mentioned situation, and the technical problem is in offering the approach of manufacturing a high Mn steel nonmagnetic welded wire mesh with the high bonding strength used for the concrete structures, such as a subgrade of a linear motor car, and a compass check apron of an airport, or reinforcement of those by low cost using the steel wire of a hot rolling as.

[0009]

[Means for Solving the Problem] this invention person acquired the following knowledge, as a result of repeating examination variously, in order to solve the above-mentioned technical problem.

[0010] (b) In weight %, especially in the high Mn steel containing C:0.10 - 1.5%, and Mn:5-30%, the amount high-melting Mn oxide carries out [ an amount ] coincidence generation with FeO, Fe 2O3, and Fe 3O4 increases in an ingredient front face, and the junction nature by electric resistance welding deteriorates remarkably with hot rolling.

[0011] (b) If high Mn steel is rolled out between heat and it rolls round at the temperature of 950 degrees C or more, thickness of the scale generated on a hot rolling steel-materials front face can be set to 10 micrometers or more.

[0012] (c) Since the scale of the high Mn steel generated at the temperature of 950 degrees C or more does not have good adhesion with steel materials, it tends to exfoliate. It generates at the temperature of 950 degrees C or more especially, and a scale 10 micrometers or more exfoliates very easily [ thickness ]. Therefore, if high Mn steel is hot-rolled, it rolls round to a coiled form above 950 degrees C and then it sets right in the shape of a straight line, since compressive force and tensile force work to the scale on the front face of a coil at the time of correction, a scale will break, and will exfoliate easily and its junction nature by electric resistance welding will improve.

[0013] (d) If it cools to the temperature of a temperature region 300 degrees C or less with the cooling rate of 5 degrees C/second or more after hot-rolling and rolling round at the temperature of 950 degrees C or more, since carbide does not deposit in the grain boundary, high Mn steel shows very good reinforcement and toughness also with hot rolling.

[0014] This invention based on the above-mentioned knowledge makes a summary the manufacture approach of the nonmagnetic welded wire mesh of following the (1) - (4).

[0015] (1) The manufacture approach of the nonmagnetic welded wire mesh characterized by arranging the high Mn steel wire of the shape of a straight line which rolled out the high Mn steel containing C:0.10 - 1.5%, and Mn:5-30% between heat, rolled round to the coiled form at the temperature of 950 degrees C or more, corrected in the shape of a straight line after that, and was subsequently corrected by weight % in the shape of a mesh, and welding those intersections by electric resistance.

[0016] (2) Cool to the temperature of a temperature region 300 degrees C or less with the cooling rate of 5 degrees C/second or more after rolling out between heat the high Mn steel which contains C:0.10 - 1.5%, and Mn:5-30% by weight % and rolling round to a coiled form at the temperature of 950 degrees C or more. The manufacture approach of the nonmagnetic welded wire mesh characterized by arranging the high Mn steel wire of the shape of a straight line which corrected in the shape of a straight line after that, and was subsequently corrected in the shape of a mesh, and welding those intersections by electric resistance.

[0017] (3) The above (1) which is that in which high Mn steel is weight % and contains Cr 3 to 6% further, and the manufacture approach of a nonmagnetic welded wire mesh given in either of (2).

[0018] (4) The manufacture approach of a nonmagnetic welded wire mesh given in either from the above (1) which is that in which high Mn steel is weight % and contains V 0.1 to 1.0% further to (3).

[0019] Here, it says intersecting perpendicularly and arranging high Mn steel wire geometrically as specified that it arranges high Mn steel wire in the shape of a mesh to JIS G 3551.

[0020]

[Embodiment of the Invention] Hereafter, each requirement for this invention is explained in detail. In addition, "% of a quantitative formula" means "% of the weight."
[0021] (A) Chemical composition C:C of the high Mn steel which is applicable is an element effective in stabilizing the austenite texture of steel and considering as nonmagnetic.
[0022] However, the effectiveness of a request of the content at less than 0.10% is not acquired, but if it exceeds 1.5%, degradation of the workability at the time between heat of cold working will be caused. Therefore, the content of C in the high Mn steel concerning this invention was made into 0.10 - 1.5%.
[0023] Mn:Mn is an element required in order to maintain steel at a nonmagnetic condition. However, the nonmagnetic condition by which the content was stabilized at less than 5% is not acquired, but if it exceeds 30%, the cost at the time of steel manufacture will increase remarkably. Therefore, the content of Mn was made into 5 - 30%.
[0024] In addition to the above-mentioned component, the high Mn steel which the approach of this invention makes an object may contain one or more sorts in Cr and V further. The operation effectiveness of these alloy elements and the desirable content are as follows.
[0025] Since Cr:Cr has the effectiveness which raises the reinforcement of high Mn steel, and corrosion resistance, it is made to contain in order to secure the big reinforcement and the corrosion resistance to a case of the structure for a nuclear-fusion experiment which needs especially earthquake resistance, but at less than 3%, the effectiveness is not acquired, but on the other hand, if contained exceeding 6%, will cause the steep rise of cost and will worsen economical efficiency. Therefore, when Cr is included, it is good to consider as 3 - 6% of content. In addition, if it is in high Mn steel, Cr of about 0.2% of amount usually mixes as an impurity by max from a dissolution raw material.
[0026] Since V:V has the effectiveness which raises reinforcement, it is made to contain in order to secure high intensity especially in the case of the reinforcement for transit ways of a linear motor car etc., but at less than 0.1%, the effectiveness is not acquired, but on the other hand, even if contained exceeding 1.0%, the improvement effectiveness in on the strength is saturated, and it becomes that cost increases. Therefore, when V is included, it is good to consider as 0.1 - 1.0% of content.
[0027] In addition, if only grant of the property required of the welded wire mesh which is a final product is possible for the high Mn steel which the approach of this invention makes an object, even if it contains other chemical entities, it does not interfere.
[0028] Specifically, you may be the high Mn steel which contains nickel:0.1-10%, N:0.010 - 0.10%, Cu:0.1-3%, and Mo:0.1-3% further in addition to C, Mn, Cr, and V. Furthermore, impurities, such as P and S, may be included.
[0029] (B) The scale on the front face of an ingredient (coil) can be made to exfoliate only by the force (compressive force and tensile force) depended for bending in case peeling of the coil is carried out 950 degrees C or more, then before welding by electric resistance and manufacturing a welded wire mesh, or rolling-up temperature in rolling-up hot rolling with hot rolling is not pickled but ** also only corrects a coil in the shape of a straight line, and lengthening. This is because a scale cannot exfoliate easily even if the adhesion of an ingredient and a scale is too good and sets right in the shape of a straight line, but 80% or more of scale on the front face of a coil will come to have the thickness of 10 micrometers or more and will exfoliate easily at the time of the correction to the shape of a straight line, if it rolls round at an elevated temperature 950 degrees C or more if the thickness of a scale is thin.
[0030] If about 80% of the scale on the front face of a coil exfoliates at least, sufficient bonding strength will be obtained by electric resistance welding.
[0031] By the way, although a coil can be made to only exfoliate only by the force depended for bending when setting right in the shape of a straight line, and lengthening as the thickness generated at the elevated temperature described above the scale 10 micrometers or more, in order to raise the product yield, it is desirable to hold down the thickness of a scale to 20 micrometers or less. And since the thickness of a scale will become thick and will come to exceed 20 micrometers if rolling-up temperature exceeds 1150 degrees C, as for the upper limit of the temperature rolled round to a coiled form with hot rolling, considering as about 1150 degrees C is desirable.
[0032] (C) What is necessary is for the correction to the shape of a straight line to be a temperature

region 500 degrees C or less, and just to perform it preferably in a temperature region 300 degrees C or less, in order to make the scale which rolled round at the temperature of 950 degrees C or more of correction to the shape of a straight line after rolling up, and was made to generate thickly exfoliate easily and to make it not make the good thin scale of adhesion with a coil generate at the time of correction. Although especially the minimum of this correction temperature does not need to limit, it should just make ordinary temperature extent minimum temperature from the field of maintenance of a facility.
[0033] By using the spinner orthodontic appliance 3 in drawing 1 for the aforementioned correction, if it carries out twisting an ingredient, the rate of exfoliation of a scale can be made still higher. By the way, it is equipment which adds the twist by rotation to coincidence and is corrected in the shape of a straight line, carrying out the bending of the ingredient to the spinner orthodontic appliance 3, as shown in drawing 1 .
[0034] In addition, if about at least 80% of the scale generated with hot rolling is made to exfoliate in the correction to the shape of an above straight line as already stated, sufficient bonding strength will be obtained by electric resistance welding.
[0035] (D) If it cools to the temperature of a temperature region 300 degrees C or less with the cooling rate of 5 degrees C/second or more after rolling round to a coiled form at the temperature of 950 degrees C or more of cooling after rolling up, since carbide does not deposit in the grain boundary, the steel wire of the high Mn steel in which very good reinforcement and toughness are shown also with hot rolling will be obtained. Therefore, when having and carrying out good reinforcement and good toughness to the welded wire mesh which is a final product, it is good to perform cooling after rolling round to a coiled form on condition that the above.
[0036] the temperature of a minimum which especially the lower limit of the temperature cooled with said cooling rate carried out does not need to limit, and is produced from the field of a cooling medium or cooling equipment -- then, it is good.
[0037] Hereafter, an example explains the approach of this invention in more detail.
[0038]
[Example] After ingoting the high Mn steel which has the chemical composition shown in Table 1 by the usual approach, slabbing was carried out to the billet.
[0039] (Example 1) Said billet of the high Mn steel A shown in Table 1 was heated at 1200 degrees C, and by the usual approach, it rolled out to the wire rod with a diameter of 8mm, and rolled round to the coiled form at 1050-900 degrees C, and after that, with SUTERUMOA air-blast-quenching equipment, it cooled to about 150 degrees C, and cooled radiationally to ordinary temperature further with the cooling rate of 5 degrees C/second.
[0040] In this way, as shown in drawing 1 , it let the coil 1 of the obtained high Mn steel A pass to the correction roller 2 and the spinner orthodontic appliance 3, it was corrected in the shape of a straight line, and the cut shear 4 cut it to the short length strand 5. In addition, arrow-head 3a in the spinner orthodontic appliance 3 in drawing 1 shows the force of bending.
[0041] Subsequently, it compared with the surface scale situation of the coil 1 before correcting the surface scale situation of a strand 5 in the shape of a straight line by viewing. Consequently, when the rolling-up temperature of the rate by which descaling was carried out was 1050 degrees C, in the case of 1000 degrees C, in the case of 950 degrees C, it was 60 - 70% about 80% about 85% 90% or more in the case of 900 degrees C.
[0042] Then, using the strand 5 manufactured with the above-mentioned monograph affair, as shown in drawing 2 , striping 5b produced [ vertical-line 5a ] every one sheet of ten welded wire meshes (width-of-face [ of 1300mm ] x die length of 2800mm) about the monograph affair by five. In addition, electric-resistance-welding conditions were performed on the same conditions as the usual WFR welded wire mesh (JIS G 3551).
[0043] After producing a welded wire mesh, the part (exfoliation part of the welding point 6) from which the welding point 6 separates and which it has not joined visually was investigated. Consequently, in the case of 1050 or 1000-degree C rolling-up temperature, there was no exfoliation of the welding

point 6, and the welding point shear strength for which it asked according to JIS G 3551 was 160-220MPa and 150-200MPa, respectively. Furthermore, 0.2% proof stress was 410-430MPa and 450-480MPa, respectively, tensile strength was 800-820MPa and 840 - 860MPa, and elongation was 30 - 35%, and 34 - 38%, respectively.

[0044] On the other hand, when rolling-up temperature was 950 degrees C and 900 degrees C, exfoliation of the welding point 6 was accepted at a rate of one place / sheet, and a three place / sheet, respectively. Moreover, the welding point shear strength for which it asked according to JIS G 3551 was 130-150MPa and 80-100MPa, respectively. Furthermore, 0.2% proof stress was 500-510MPa and 540-550MPa, respectively, tensile strength was 860-870MPa and 880 - 890MPa, and elongation was 28 - 30%, and 25 - 26%, respectively.

[0045] That is, the nonmagnetic welded wire mesh manufactured by the approach of this invention has high bonding strength, and the mechanical property satisfies the value of standard of JIS G 3551.

[0046] (Example 2) The dimension which heated said billet of the high Mn steel B shown in Table 1 at 1200 degrees C, and was based on JIS G 3112 by the usual approach rolled round the deformed bar of a mnemonic name D13 to the coiled form at 1050 degrees C, rolled out to the bar-in coil, and cooled radiationally to ordinary temperature further.

[0047] In addition, a "bar-in coil" is what rolled round the steel bar to the coiled form with the winding machine like the wire rod for the purpose of the yield, improvement in processing efficiency, etc., and drawing or straight-line processing is performed continuously after this, and it considers as a steel bar.

[0048] In the example 1, similarly, it let the bar-in coil of the high Mn steel B obtained as mentioned above pass to the correction roller 2 and the spinner orthodontic appliance 3, it was corrected in the shape of a straight line, and the cut shear 4 cut it to the short length strand 5 (refer to drawing 1 ).

[0049] Then, using the above-mentioned strand 5, as shown in drawing 2 , striping 5b produced [ vertical-line 5a ] ten sheets of ten welded wire meshes (width-of-face [ of 1300mm ] x die length of 2800mm) by five.

[0050] In addition, electric-resistance-welding conditions were performed on the same conditions as the usual WFR welded wire mesh.

[0051] After producing a welded wire mesh, the exfoliation part of the welding point 6 was investigated visually. Consequently, there was no exfoliation of the welding point 6, and the welding point shear strength for which it asked according to JIS G 3112 was 150-180MPa. Furthermore, 0.2% proof stress was 500-520MPa, tensile strength was 900 - 920MPa, and elongation was 40 - 42%.

[0052] That is, the nonmagnetic welded wire mesh manufactured by the approach of this invention has high bonding strength, and the mechanical property satisfies the value of standard of JIS G 3551.

[0053] (Example 3) The dimension which heated said billet of the high Mn steel C shown in Table 1 at 1200 degrees C, and was based on JIS G 3112 by the usual approach rolled round the deformed bar of a mnemonic name D12 to the coiled form at 1000 degrees C, it rolled out to the bar-in coil, air blast quenching was carried out with 50-degree-C cooling rate for /to 300 more degrees C, and it cooled radiationally after that.

[0054] Subsequently, in the example 2, it let it pass to the correction roller 2 and the spinner orthodontic appliance 3, and set right in the shape of a straight line, and the cut shear 4 cut to the short length strand 5 similarly (refer to drawing 1).

[0055] Then, using the above-mentioned strand 5, as shown in drawing 2 , striping 5b produced [ vertical-line 5a ] ten sheets of ten welded wire meshes (width-of-face [ of 1300mm ] x die length of 2800mm) by five.

[0056] In addition, electric-resistance-welding conditions were performed on the same conditions as the usual WFR welded wire mesh.

[0057] After producing a welded wire mesh, the exfoliation part of the welding point 6 was investigated visually. Consequently, there was no exfoliation of the welding point 6, and the welding point shear strength for which it asked according to JIS G 3112 was 150-180MPa. Furthermore, 0.2% proof stress was 550-560MPa, tensile strength was 860 - 870MPa, and elongation was 38 - 40%.

[0058] That is, the nonmagnetic welded wire mesh manufactured by the approach of this invention has

high bonding strength, and the mechanical property satisfies the value of standard of JIS G 3551.
[0059]
[Table 1]

表 1

| 鋼種 | 化学組成（重量%） 残部：Fe及び不純物 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | Mn | Cr | V | Si | P | S | Cu | Ni | Mo | N |
| A | 0.48 | 18.5 | 4.50 | — | 0.45 | 0.025 | 0.005 | 0.01 | 0.03 | 0.02 | 0.020 |
| B | 0.95 | 13.5 | 0.10 | 0.15 | 0.40 | 0.020 | 0.003 | 0.01 | 0.02 | 0.01 | 0.026 |
| C | 0.99 | 12.5 | 0.05 | — | 0.35 | 0.030 | 0.005 | 0.01 | 0.02 | 0.02 | 0.015 |

[0060]
[Effect of the Invention] Since a nonmagnetic welded wire mesh with high bonding strength can be manufactured by low cost using the high Mn steel wire of a hot rolling as according to the manufacture approach of the nonmagnetic welded wire mesh of this invention as explained above, the effectiveness on industry is very large.

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[Translation done.]

* NOTICES *



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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the correction approach of the high Mn steel coil in an example.
[Drawing 2] It is drawing showing the welded wire mesh produced in the example.
[Description of Notations]
1: Coil,
2: Correction roller,
3: Spinner orthodontic appliance,
3a: Force of bending,
4: Cut shear,
5: Strand,
5a: Vertical line,
5b: Striping,
6: A welding point,

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[Translation done.]

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(54)【発明の名称】　非磁性溶接金網の製造方法

(57)【要約】
【課題】接合強度の高い高Ｍｎ鋼製非磁性溶接金網を熱間圧延ままの鋼線を用いて低コストで製造する方法を提供する。
【解決手段】Ｃ：０．１０～１．５%、Ｍｎ：５～３０%を含む高Ｍｎ鋼を熱間で圧延して９５０℃以上の温度でコイル状に巻取り、その後直線状に矯正し、次いで矯正した直線状の高Ｍｎ鋼線を網目状に配列し、それらの交点を電気抵抗溶接する。コイル状に巻取った後、５℃／秒以上の冷却速度で３００℃以下の温度域の温度まで冷却すれば最終製品である溶接金網の特性が向上する。高Ｍｎ鋼がＣｒを３～６%、Ｖを０．１～１．０%含んでおれば強度や耐食性が高まる。

1

【特許請求の範囲】

【請求項1】重量％で、C：0．10～1．5％、Mn：5～30％を含む高Mn鋼を熱間で圧延して950℃以上の温度でコイル状に巻取り、その後直線状に矯正し、次いで矯正した直線状の高Mn鋼線を網目状に配列し、それらの交点を電気抵抗溶接することを特徴とする非磁性溶接金網の製造方法。

【請求項2】重量％で、C：0．10～1．5％、Mn：5～30％を含む高Mn鋼を熱間で圧延して950℃以上の温度でコイル状に巻取った後5℃／秒以上の冷却速度で300℃以下の温度域の温度まで冷却し、その後直線状に矯正し、次いで矯正した直線状の高Mn鋼線を網目状に配列し、それらの交点を電気抵抗溶接することを特徴とする非磁性溶接金網の製造方法。

【請求項3】高Mn鋼が重量％で、更に、Crを3～6％含むものである請求項1と2のいずれかに記載の非磁性溶接金網の製造方法。

【請求項4】高Mn鋼が重量％で、更に、Vを0．1～1．0％含むものである請求項1から3までのいずれかに記載の非磁性溶接金網の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、非磁性溶接金網の製造方法に関し、より詳しくはリニアモータカーの路床や空港のコンパスチェックエプロンなどのコンクリート構造物やその補強に使用される高Mn鋼製非磁性溶接金網を熱間圧延ままの鋼線を用いて製造する方法に関する。

【0002】

【従来の技術】リニアモータカーの路床や核融合炉などの構造部材は高い磁場中での磁化や発熱などを防止するために、又、空港のコンパスチェックエプロンの構造部材は航空機のコンパスチェックを可能とするために、透磁率の低い非磁性鋼材が用いられている。こうした非磁性構造部材の中でも、コンクリート構造物用及び補強用として使用される溶接金網の素材には、一般にJISのSUS304などのオーステナイト系ステンレス鋼やSCMnH2などの所謂「ハッドフィールド鋼」と呼ばれる高Mn鋼が使用されてきた。

【0003】しかし、オーステナイト系ステンレス鋼は高価なNiやCrを多量に含むため高価であり、又、降伏点が低いため素材の寸法（径）を大きくしなければならないという問題があった。加えて、寸法を大きくすることは更なるコスト上昇を招くものであった。

【0004】これに対して、高Mn鋼は高強度で且つ安定な非磁性を示し、更に、オーステナイト系ステンレス鋼と比べて安価である。しかし、溶接性の点で問題があるので手作業による配筋及び結束が行われ、施工に多大の経費を要していた。

【0005】高Mn鋼製金網の製造方法としては、特公昭60－40498号公報に高Mn鋼線を波状に曲げ加工した後で波状間を網に編むクリンプ金網の製造方法が提案されている。しかし、この方法で製造された金網の接合強度は低くコンクリート構造物用及び補強用としては使用に耐えないものである。

2

【0006】一方、特公昭57－40901号公報にはNiを0．3～3．0重量％含む「溶接性および被削性に優れた非磁性高マンガン鋼」が提案されている。しかしながら前記公報に提案された高Mn鋼を素材として用いても、熱間圧延ままの鋼線を網目状に配列し、それらの交点を電気抵抗溶接するだけでは、溶接点が外れたり接合できても接合強度は低いものであった。これは熱間圧延で生じた酸化物（以下、「スケール」ともいう）が電気抵抗溶接時の接合性を劣化させるためである。

【0007】すなわち熱間圧延された鉄鋼材料の表面には$FeO$ 、$Fe_2O_3$ 、$Fe_3O_4$ の酸化物が生成するが、高Mn鋼の場合にはこれらに加えて高融点のMn酸化物が同時に生成し、これが電気抵抗溶接時の接合性を劣化させる。従って、電気抵抗溶接で充分な接合強度を付与するためには、熱間圧延した高Mn鋼線をピーリングしたり酸洗いしたりしてスケール、なかでも高融点のMn酸化物を除去する必要がある。しかしこの場合には製造工程が煩雑になり、更にコストも嵩んでしまう。

【0008】

【発明が解決しようとする課題】本発明は、上記した状況に鑑みなされたもので、その課題は、リニアモータカーの路床や空港のコンパスチェックエプロンなどのコンクリート構造物やその補強に使用される接合強度の高い高Mn鋼製非磁性溶接金網を熱間圧延ままの鋼線を用いて低コストで製造する方法を提供することにある。

【0009】

【課題を解決するための手段】本発明者は、上記の課題を解決するため種々検討を重ねた結果、下記の知見を得た。

【0010】（イ）重量％で、C：0．10～1．5％、Mn：5～30％を含む高Mn鋼においては特に熱間圧延で材料表面に高融点のMn酸化物が$FeO$ 、$Fe_2O_3$ 、$Fe_3O_4$と同時生成する量が多くなり、電気抵抗溶接による接合性が著しく劣化する。

【0011】（ロ）高Mn鋼を熱間で圧延して950℃以上の温度で巻取れば、熱間圧延鋼材表面に生成するスケールの厚みを10μm以上にすることができる。

【0012】（ハ）950℃以上の温度で生成した高Mn鋼のスケールは鋼材との密着性が良くないので剥離し易い。なかでも950℃以上の温度で生成し、且つ、厚みが10μm以上のスケールは極めて容易に剥離する。従って、高Mn鋼を熱間圧延して950℃以上でコイル状に巻取り、次に直線状に矯正すれば、矯正時にコイル表面のスケールには圧縮力と引張力が働くのでスケールは割れて容易に剥離し、電気抵抗溶接による接合性が向

上する。

【0013】(ニ) 高Mn鋼は、熱間圧延して950℃以上の温度で巻取った後、5℃／秒以上の冷却速度で300℃以下の温度域の温度まで冷却すれば、結晶粒界に炭化物が析出することもないので熱間圧延のままでも極めて良好な強度と靭性を示す。

【0014】上記知見に基づく本発明は、下記（1）～（4）の非磁性溶接金網の製造方法を要旨とする。

【0015】（1）重量%で、C：0．10～1．5%、Mn：5～30%を含む高Mn鋼を熱間で圧延して950℃以上の温度でコイル状に巻取り、その後直線状に矯正し、次いで矯正した直線状の高Mn鋼線を網目状に配列し、それらの交点を電気抵抗溶接することを特徴とする非磁性溶接金網の製造方法。

【0016】（2）重量%で、C：0．10～1．5%、Mn：5～30%を含む高Mn鋼を熱間で圧延して950℃以上の温度でコイル状に巻取った後5℃／秒以上の冷却速度で300℃以下の温度域の温度まで冷却し、その後直線状に矯正し、次いで矯正した直線状の高Mn鋼線を網目状に配列し、それらの交点を電気抵抗溶接することを特徴とする非磁性溶接金網の製造方法。

【0017】（3）高Mn鋼が重量%で、更に、Crを3～6%含むものである上記（1）及び（2）のいずれかに記載の非磁性溶接金網の製造方法。

【0018】（4）高Mn鋼が重量%で、更に、Vを0．1～1．0%含むものである上記（1）から（3）までのいずれかに記載の非磁性溶接金網の製造方法。

【0019】ここで、高Mn鋼線を網目状に配列するとは、JIS G 3551に規定されているように、高Mn鋼線を直交して幾何学的に配列することをいう。

【0020】

【発明の実施の形態】以下、本発明の各要件について詳しく説明する。なお成分含有量の「%」は「重量%」を意味する。

【0021】（A）対象となる高Mn鋼の化学組成

C：Cは鋼のオーステナイト組織を安定化し非磁性とするのに有効な元素である。

【0022】しかし、その含有量が0．10%未満では所望の効果が得られず、1．5%を超えると熱間及び冷間加工時の加工性の劣化をきたす。従って、本発明に係る高Mn鋼におけるCの含有量を0．10～1．5%とした。

【0023】Mn：Mnは鋼を非磁性状態に保つために必要な元素である。しかし、その含有量が5%未満では安定した非磁性状態が得られず、30%を超えると製鋼時のコストが著しく嵩んでしまう。従って、Mnの含有量を5～30%とした。

【0024】本発明の方法が対象とする高Mn鋼は、上記の成分に加えて更に、Cr及びVのうちの1種以上を含んでいても良い。これらの合金元素の作用効果と望ましい含有量は下記のとおりである。

【0025】Cr：Crは高Mn鋼の強度と耐食性を高める効果を有するため、特に耐震性が必要な核融合実験用構造物などの場合に大きな強度と耐食性を確保する目的で含有させるが、3%未満ではその効果が得られず、一方、6%を超えて含有するとコストの大幅な上昇をきたし経済性を悪くする。従って、Crを含む場合には3～6%の含有量とするのが良い。なお、高Mn鋼にあっては、通常溶解原料から最大で0．2%程度の量のCrが不純物として混入してくる。

【0026】V：Vは強度を高める効果を有するため、特にリニアモータカーの走行路用鉄筋などの場合に高強度を確保する目的で含有させるが、0．1%未満ではその効果が得られず、一方、1．0%を超えて含有しても強度向上効果が飽和してコストが嵩むばかりとなる。従って、Vを含む場合には0．1～1．0%の含有量とするのが良い。

【0027】なお、本発明の方法が対象とする高Mn鋼は、最終製品である溶接金網に要求される特性の付与が可能でありさえすれば、他の化学成分を含むものであっても差し支えない。

【0028】具体的には、例えば、C、Mn、CrとV以外に更に、Ni：0．1～10%、N：0．010～0．10%、Cu：0．1～3%、Mo：0．1～3%を含むような高Mn鋼であっても良い。更に、PやSといった不純物を含んでいても良い。

【0029】（B）熱間圧延での巻取り

熱間圧延での巻取り温度を950℃以上とすれば、電気抵抗溶接して溶接金網を製造する前にコイルをピーリングしたり酸洗いしたりせずとも、単にコイルを直線状に矯正する時の曲げ伸ばしによる力（圧縮力と引張力）だけで材料（コイル）表面のスケールを剥離させることができる。これは、スケールの厚みが薄いと材料とスケールの密着性が良すぎて直線状に矯正してもスケールが剥離し難いが、950℃以上の高温で巻取ればコイル表面の80%以上のスケールが10μm以上の厚みを有するようになって直線状への矯正時に容易に剥離するからである。

【0030】少なくともコイル表面のスケールの80%程度が剥離すれば電気抵抗溶接によって充分な接合強度が得られる。

【0031】ところで、高温で生成した厚みが10μm以上のスケールは上記したように、単にコイルを直線状に矯正する時の曲げ伸ばしによる力だけで剥離させることができるが、製品歩留まりを高めるためにはスケールの厚みを20μm以下に抑えることが好ましい。そして、巻取り温度が1150℃を超えるとスケールの厚みが厚くなって20μmを超えるようになるので、熱間圧延でコイル状に巻取る温度の上限は1150℃程度とすることが望ましい。

【0032】（C）巻取り後の直線状への矯正
９５０℃以上の温度で巻取って厚く生成させたスケールを容易に剥離させて、且つ、矯正時にコイルとの密着性の良い薄いスケールを生成させないようにするためには、直線状への矯正は５００℃以下の温度域で、好ましくは３００℃以下の温度域で行えば良い。この矯正温度の下限は特に限定する必要はないが、設備の保守の面から常温程度を下限温度とすれば良い。

【0033】前記の矯正を、例えば図１におけるスピンナー矯正装置３を用いることによって、材料を捻りながら行えばスケールの剥離率を一層高くすることができる。ところでスピンナー矯正装置３とは、図１に示すように材料をベンディングさせながら、同時に回転による捻りを加えて直線状に矯正する装置である。

【0034】なお既に述べたように、上記の直線状への矯正で、熱間圧延で生成したスケールの少なくとも８０％程度を剥離させれば、電気抵抗溶接によって充分な接合強度が得られる。

【0035】（D）巻取り後の冷却
９５０℃以上の温度でコイル状に巻取った後、５℃／秒以上の冷却速度で３００℃以下の温度域の温度まで冷却すれば、結晶粒界に炭化物が析出することがないので熱間圧延のままでも極めて良好な強度と靭性を示す高Ｍｎ鋼の鋼線が得られる。従って、最終製品である溶接金網に対して良好な強度と靭性を備えさせたい場合には、コイル状に巻取った後の冷却は上記の条件で行うのが良い。

【0036】前記した冷却速度で冷却する温度の下限値は特に限定する必要はなく、冷却媒体や冷却設備の面から生ずる下限の温度とすれば良い。

【0037】以下、実施例により本発明の方法を更に詳しく説明する。

【0038】

【実施例】表１に示す化学組成を有する高Ｍｎ鋼を通常の方法によって溶製した後ビレットに分塊圧延した。

【0039】（実施例１）表１に示した高Ｍｎ鋼Ａの前記ビレットを１２００℃に加熱して通常の方法によって直径８ｍｍの線材に圧延し、１０５０～９００℃でコイル状に巻取り、その後ステルモア風冷装置で５℃／秒の冷却速度で約１５０℃まで冷却し、更に常温まで放冷した。

【0040】こうして得られた高Ｍｎ鋼Ａのコイル１を、図１に示すように、矯正ローラー２及びスピンナー矯正装置３に通して直線状に矯正し、カットシャー４で短尺の素線５に切断した。なお図１中スピンナー矯正装置３における矢印３ａはベンディングの力を示す。

【0041】次いで、目視によって素線５の表面スケール状況を直線状に矯正する前のコイル１の表面スケール状況と比較した。その結果、脱スケールされた割合は、巻取り温度が１０５０℃の場合は９０％以上、１０００℃の場合は８５％程度、９５０℃の場合は８０％程度、９００℃の場合は６０～７０％であった。

【0042】この後、上記の各条件で製造した素線５を用いて、図２に示すように縦線５ａが５本で横線５ｂが１０本の溶接金網（幅１３００ｍｍ×長さ２８００ｍｍ）を各条件について１枚ずつ作製した。なお、電気抵抗溶接条件は通常のＷＦＲ溶接金網（JIS G 3551）と同じ条件で行った。

【0043】溶接金網を作製した後は、目視で溶接点６が外れて接合していない箇所（溶接点６の剥離箇所）を調査した。その結果、巻取り温度１０５０、１０００℃の場合には溶接点６の剥離は皆無であり、又、JIS G 3551に準じて求めた溶接点剪断強度はそれぞれ１６０～２２０ＭＰａと１５０～２００ＭＰａであった。更に、０．２%耐力はそれぞれ４１０～４３０ＭＰａ、４５０～４８０ＭＰａで、引張強度はそれぞれ８００～８２０ＭＰａ、８４０～８６０ＭＰａ、伸びはそれぞれ３０～３５％と３４～３８％であった。

【0044】一方、巻取り温度が９５０℃と９００℃の場合にはそれぞれ１箇所／シートと３箇所／シートの割合で溶接点６の剥離が認められた。又、JIS G 3551に準じて求めた溶接点剪断強度はそれぞれ１３０～１５０ＭＰａと８０～１００ＭＰａであった。更に、０．２%耐力はそれぞれ５００～５１０ＭＰａ、５４０～５５０ＭＰａで、引張強度はそれぞれ８６０～８７０ＭＰａ、８８０～８９０ＭＰａ、伸びはそれぞれ２８～３０％と２５～２６％であった。

【0045】すなわち、本発明の方法で製造した非磁性溶接金網は接合強度が高く、その機械的性質はJIS G 3551の規格値を満足するものである。

【0046】（実施例２）表１に示した高Ｍｎ鋼Ｂの前記ビレットを１２００℃に加熱して通常の方法によって、JIS G 3112に準拠した寸法が呼び名Ｄ１３の異形棒鋼を１０５０℃でコイル状に巻取ってバーインコイルに圧延し、更に常温まで放冷した。

【0047】なお「バーインコイル」とは、歩留まりや加工能率の向上などを目的に棒鋼を線材と同様に巻線機でコイル状に巻取ったもので、この後連続的に引き抜き又は直線加工を行って棒鋼とされるものである。

【0048】上記のようにして得た高Ｍｎ鋼Ｂのバーインコイルを、実施例１におけると同様に、矯正ローラー２及びスピンナー矯正装置３に通して直線状に矯正し、カットシャー４で短尺の素線５に切断した（図１参照）。

【0049】この後、上記の素線５を用いて、図２に示すように縦線５ａが５本で横線５ｂが１０本の溶接金網（幅１３００ｍｍ×長さ２８００ｍｍ）を１０枚作製した。

【0050】なお、電気抵抗溶接条件は通常のＷＦＲ溶接金網と同じ条件で行った。

【0051】溶接金網を作製した後は、目視で溶接点6の剥離箇所を調査した。その結果、溶接点6の剥離は皆無であり、又、JIS G 3112に準じて求めた溶接点剪断強度は150～180MPaであった。更に、0．2%耐力は500～520MPaで、引張強度は900～920MPa、伸びは40～42%であった。

【0052】すなわち、本発明の方法で製造した非磁性溶接金網は接合強度が高く、その機械的性質はJIS G 3551の規格値を満足するものである。

【0053】（実施例3）表1に示した高Mn鋼Cの前記ビレットを1200℃に加熱して通常の方法によって、JIS G 3112に準拠した寸法が呼び名D12の異形棒鋼を1000℃でコイル状に巻取ってバーインコイルに圧延し、更に300℃まで50℃／分の冷却速度で風冷し、その後は放冷した。

【0054】次いで、実施例2におけると同様に、矯正ローラー2及びスピンナー矯正装置3に通して直線状に矯正し、カットシャー4で短尺の素線5に切断した（図＊1参照）。

【0055】この後、上記の素線5を用いて、図2に示すように縦線5aが5本で横線5bが10本の溶接金網（幅1300mm×長さ2800mm）を10枚作製した。

【0056】なお、電気抵抗溶接条件は通常のWFR溶接金網と同じ条件で行った。

【0057】溶接金網を作製した後は、目視で溶接点6の剥離箇所を調査した。その結果、溶接点6の剥離は皆無であり、又、JIS G 3112に準じて求めた溶接点剪断強度は150～180MPaであった。更に、0．2%耐力は550～560MPaで、引張強度は860～870MPa、伸びは38～40%であった。

【0058】すなわち、本発明の方法で製造した非磁性溶接金網は接合強度が高く、その機械的性質はJIS G 3551の規格値を満足するものである。

【0059】

【表1】

表 1

| 鋼種 | 化学組成（重量%） 残部：Fe及び不純物 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | Mn | Cr | V | Si | P | S | Cu | Ni | Mo | N |
| A | 0.48 | 18.5 | 4.50 | − | 0.45 | 0.025 | 0.005 | 0.01 | 0.03 | 0.02 | 0.020 |
| B | 0.95 | 13.5 | 0.10 | 0.15 | 0.40 | 0.020 | 0.003 | 0.01 | 0.02 | 0.01 | 0.026 |
| C | 0.99 | 12.5 | 0.05 | − | 0.35 | 0.030 | 0.005 | 0.01 | 0.02 | 0.02 | 0.015 |

【0060】

【発明の効果】以上説明したように、本発明の非磁性溶接金網の製造方法によれば熱間圧延ままの高Mn鋼線を用いて接合強度の高い非磁性溶接金網を低コストで製造することができるので、産業上の効果は極めて大きい。

【図面の簡単な説明】

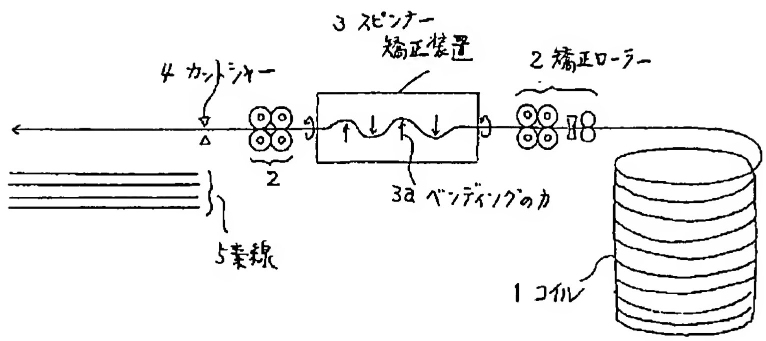
【図1】実施例における高Mn鋼コイルの矯正方法を示す図である。

【図2】実施例で作製した溶接金網を示す図である。

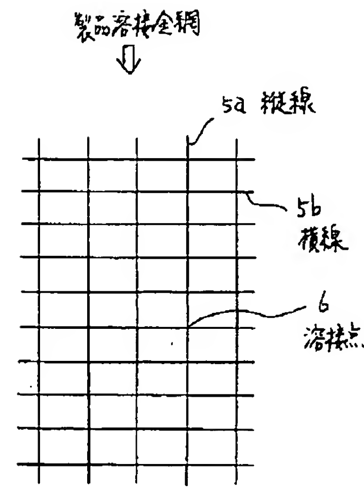
【符号の説明】

※1：コイル、
2：矯正ローラー、
3：スピンナー矯正装置、
3a：ベンディングの力、
4：カットシャー、
5：素線、
5a：縦線、
5b：横線、
6：溶接点、

【図1】




【図2】

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